A ziphodont crocodile from the late Pleistocene King Creek catchment, Darling Downs, Queensland.

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ABSTRACT

A well preserved reptilian tooth recovered from late Pleistocene fluviatile sediments along King Creek on the Darling Downs, south eastern Queensland, displays a suite of characters including lateral compression and curvature, lenticular cross section, length/width ratio >1.3, slight anterior/posterior recurve and distinct, strongly serrate carinae, that enable it to be attributed to a ziphodont crocodile (*Quinkana* sp.). It is the first record of a ziphodont in the King Creek ecosystem and only the second for the eastern Darling Downs in over 150 years of fossil collecting. This tooth as well as previously documented fossils from Tea Tree Cave (N. Qld) and Texas Caves (S. Qld) provides the youngest records of ziphodont crocodiles globally.□ *Ziphodont, Crocodile, Quinkana, King Creek, Darling Downs, Pleistocene.*

A high diversity of large bodied reptilian carnivores, including varanids and crocodilians, inhabited the late Pleistocene ecosystems of south eastern Queensland. Within the fossil collections of the Queensland Museum, the giant varanid *Varanus priscus* (formerly *Megalania prisca*) is the most abundant having been recorded in deposits from several sub-catchments throughout the Darling Downs, but being best known from the intensively studied King Creek catchment (Molnar & Kurz 1997; Price & Sobbe 2005; Price & Webb 2006). Crocodiles, principally *Pallimnarchus pollens* and *Crocodylus porosus*, have also been recorded from a range of Darling Downs localities (Molnar & Kurz 1997; Price & Webb 2006).

In their review of eastern Darling Downs Pleistocene vertebrates in the collection of the Queensland Museum, Molnar & Kurz (1997) concluded that ziphodont crocodiles seem to have been absent from the region during the Pleistocene, although an earlier paper (Molnar 1981) listed a single ziphodont tooth crown from either Westbrook Creek or Gowrie Creek, northwest of Toowoomba in the collection of the Australian Museum (AMF2876). A newly collected fossil is the first record of a ziphodont crocodile in the King Creek catchment. The purpose of this paper is to report the palaeontological significance of this specimen.

MATERIALS AND METHODS

The specimen as collected was robust and did not require special preparation or preservation techniques. All measurements are in metric

units using digital callipers or calibrated eyepiece micrometer. Higher systematics follow Molnar (1981) and Willis *et al.* (1993). Institutional abbreviations include: AMF, Fossil collection of the Australian Museum, Sydney. QMF, Fossil collection of the Queensland Museum, Brisbane.

SYSTEMATIC PALAEONTOLOGY

Family CROCODYLIDAE Cuvier, 1807

Subfamily MEKOSUCHINAE Willis, Molnar and Scanlon 1993

Quinkana Molnar, 1981

Quinkana sp.

Material. QMF57032. (Fig. 1A-C) An isolated tooth crown from fluviatile sediments exposed in the naturally eroded bank of King Creek, west of Pilton, eastern Darling Downs, Queensland. Specific locality details are recorded in the Queensland Museum fossil register.

Geological Age. QMF57032 has not been directly dated but is considered to be late Pleistocene based on the abundance of other late Pleistocene deposits in the King Creek catchment (see Price & Sobbe 2005; Price & Webb 2006; Price *et al.* 2011) and the presence of other late Pleistocene species such as *Diprotodon optatum, Macropus ferragus, Macropus titan, Protemnodon anak, Troposodon minor, Varanus priscus* in the adjacent area (Molnar & Kurz 1997). The oldest geological age of sediments containing fossils of megafauna, currently recorded in the King Creek catchment is an optically stimulated luminescence age of 122 ± 22 ka. (Price *et al.* 2011).

Description. The tooth crown is 29.9 mm long, tapers distally, and is laterally compressed and lenticular in cross section. The surface texture of the enamel is well detailed with little evidence of stream abrasion although several small post mortem chips are present and there is evidence of chemical corrosion from plant roots. The enamel shows no evidence of vertical

Fig. 1. A - C. QMF57032, ziphodont crocodilian tooth (*Quinkana* sp.). A, Lateral view of lingual surface; B, Posterior surface; C, Lateral view of buccal surface. At right, a magnified view of portion of carina showing the serrate edge. An occlusal wear facet is visible on the tip of the tooth in A and B.

TABLE 1. Comparative features of the teeth of large late Pleistocene reptilian carnivores and the King Creek ziphodont crocodile (QMF57032).

Character	*Varanus priscus*	*Crocodylus porosus*	*Crocodylus johnstoni*	*Pallimnarchus pollens*	*Quinkana* sp.	QMF57032
Tooth crown shape	Laterally compressed elongate	Robust conical	Slender conical (small)	Robust conical laterally curved	Laterally compressed and curved	Laterally compressed and curved
Crosssectional shape	Tear shaped	Ovoid to Round	Ovoid	Ovoid	Lenticular	Lenticular
Lateral shape	Strong recurve posterior margin concave	Blunt tapering Slightly curved	Long slender evenly tapering	Blunt Evenly tapered	Tapered Slightly recurved	Tapered Slightly recurved
Length / Width Ratio	> 1.3	< 1.3	Not measured	< 1.3	> 1.3	1.36 to 1.59
Fluting / Ridging	Strong basal Irregular	Weak	Weak	Absent	Absent	Absent
Carinae	Anterior - Distal 30% only Posterior 100%	Poorly developed	Poorly developed	Distinct	Distinct	Distinct
Carinae Serrations	Strongly serrate	Non serrate	Non serrate	Serrate	Strongly serrate	Strongly serrate

fluting or ridging. The tooth measures 13.6 mm x 10 mm in greatest basal dimensions (length /width ratio = 1.36) and at approximately 50% of the crown height it measures 12.1 mm x 7.6 mm (length/width ratio = 1.59) thus becoming increasingly laterally compressed dorsally. It has pronounced lateral curvature with slight anterior/posterior recurve, with well developed carinae along the complete anterior and posterior margins. Both carinae are finely serrate along their entire length (25–26 serrations per 5 mm). There is a cup in the base of the crown in the shape of an oval cone, 8 mm in depth. A small occlusal wear facet 7 mm x 3.2 mm is present postero-distally.

Remarks. Willis and Molnar (1997) provided a set of characters that aided identification of isolated large reptilian teeth. These characters are observable on QMF57032 allowing it to be confidently identified (Table 1). For comparative photographs of the teeth of other large reptilian taxa discussed below, see Willis and Molnar (1997).

QMF57032 is not referable to *Varanus priscus* because their teeth are much more distally tapered and heavily recurved making the posterior margin concave. Additionally *V. priscus* has pronounced basal fluting and the anterior carina is serrate only for the distal third of its length.

QMF57032 differs from *Crocodylus porosus* because their teeth are ovoid and less flattened in cross section and have poorly developed, non serrate carinae. Willis and Molnar (1997) described *C. porosus* teeth as smooth and only rarely having basal ridging. However all

specimens examined for this study including the photos in Willis and Molnar (1997, p. 83) showed distinct basal ridging and thus differs from QMF57032.

Crocodylus johnstoni teeth are much smaller and more slender than QMF57032 and have poorly developed carinae with no serrations. They also commonly have weak basal ridging or fluting.

Teeth of *Pallimnarchus pollens* have a more symmetrical profile than QMF57032, are rounder in cross section (length / width ratio < 1.3), but have distinct carinae that are occasionally serrate.

In contrast, teeth of *Quinkana* are laterally curved with slight posterior recurve, laterally compressed (length / width ratio > 1.3) with well developed carinae that are serrate along their entire length. QMF57032 shares these characters and is accordingly referred of this genus of ziphodont crocodile. The holotype specimen (AMF57844) of the type species of the genus, *Q. fortirostrum* from Tea Tree Cave, is edentulous (teeth are missing) thus not allowing for direct comparison with QMF57032. The only other Pleistocene ziphodont with retained dentition, (QMF7898, *Quinkana* sp.) from 'The Joint', Texas Caves is poorly preserved (Molnar 1981) and only allows superficial comparison of the dentition; however it appears at least superficially morphologically similar to QMF57032.

QMF57032 differs from *Quinkana meboldi* (Late Oligocene) in that unlike other species of *Quinkana*, *Q. meboldi* teeth have carinae without serrations (Willis 1997). QMF57032 differs from *Quinkana timara* (Miocene) because *Q. timara* teeth are much smaller (approx. 50% of linear dimensions) and the carinae are more finely serrate (Megirian 1994). Compared to QMF57032, the teeth of *Quinkana babarra* (Early Pliocene) appear broader, less laterally curved and slightly more anterio- posteriorly recurved (Willis and Mackness 1997). A small terrestrial mekosuchine crocodile has also been recorded from the middle Pleistocene Mt. Etna caves system (Hocknull 2005). The tooth varies from QMF57032 in that it is much smaller, relatively broader and the carinae serrations are much coarser.

QMF57032 appears morphologically closest to *Quinkana* sp. cf. *Q. fortirostrum* teeth described by Willis & Molnar (1997). However, all species of *Quinkana* are described from specimens with limited retained teeth or only associated teeth. Until additional, more complete specimens are available for study, assignment of single teeth such as QMF57032 to a specific species seems premature.

DISCUSSION

QMF57032 represents the first record of a ziphodont crocodilian in the late Pleistocene King Creek catchment and only the second for the entire (Pleistocene) eastern Darling Downs in over 150 years of fossil collecting. Given the high replacement rate of crocodilian teeth (Willis & Molnar 1997) and the paucity of the fossil record, we conclude that ziphodont crocodiles were a very rare component of late Pleistocene Darling Downs ecosystems. In contrast, ziphodont teeth are much better represented in the Pliocene fossil deposits at Chinchilla on the western Darling Downs (Molnar 1981) possibly indicating a post-Pliocene decline in abundance on the Darling Downs.

Outside of Australia, the youngest records of crocodiles with ziphodont morphologies are Miocene, while within Australia the ziphodont (or semi-ziphodont) record ranges from the Eocene to Pleistocene (Molnar 1981; Willis *et al.* 1993; Willis & Mackness 1996). Thus, recognition of QMF57032 as *Quinkana* sp. on the late Pleistocene Darling Downs as well as *Q. fortirostrum* from the undated but probably Pleistocene Tea Tree Cave of north Queensland and *Quinkana* sp. from the probably middle Pleistocene (Price *et al.* 2009) Texas Caves in south Queensland, represent the youngest known records of crocodiles with ziphodont morphologies not only for Australia, but globally.

Molnar (1981), Flannery (1994) and Willis & Mackness (1996) noted the preponderance of large-bodied terrestrial reptilian carnivores in Pleistocene Australia is unlike that of

most modern faunas which typically contain markedly more diverse large-bodied terrestrial mammalian carnivores. The three largest-bodied mammalian carnivores recorded in the late Pleistocene King Creek catchment include *Thylacoleo carnifex* (ca. 100–150 kg), *Thylacinus cynocephalus* (ca. 15–35 kg) and *Sarcophilus laniarius* (ca. 10–20 kg). Such species were dwarfed in size by Pleistocene reptilian counterparts including *Quinkana* sp. (ca. 200 kg) and *Varanus priscus* (ca. 600 kg), as well as the semi-aquatic *Pallimnarchus* sp. (ca. 1000 kg). Interestingly, such a dominance of large-bodied non-mammalian carnivores is not evident in older fossil deposits, such as those from the Miocene. Rather, most Miocene deposits, such as those from Riversleigh, are dominated, in terms of diversity, by relatively large-bodied mammalian carnivores (Wroe *et al.* 1999). Pliocene deposits, such as those from Chinchilla (western Darling Downs) are more similar to those from the Pleistocene King Creek catchment in that they are dominated by large-bodied reptilian carnivores (*Pallimnarchus pollens*, *P. gracilis*, *Quinkana* sp., *Varanus priscus* and *V. komodoensis* which are each 200 kg or greater, versus the largest known mammalian carnivore *T. crassidentatus* which was likely <100 kg). Thus, there must have been an unprecedented 'taxonomic-ecological shift' in the makeup of large-bodied carnivores sometime after the Miocene, shifting from dominantly mammals to dominantly reptiles. Such a shift appears to have been in place from at least the Pliocene, and lasting as recently as the late Pleistocene. A cause of such a marked transition is unclear.

Palaeohabitats appear to have changed markedly in south-eastern Queensland between the Pliocene and late Pleistocene, principally reflecting the contraction of closed woodlands and expansion of grasslands, driven by an overall trend towards an increasingly arid climate (Price 2012). The late Pleistocene King Creek ecosystems also underwent significant changes in the early part of the last glacial cycle (i.e., from ca. 120–80 ka) with significant forest and vine scrub thicket contractions giving way to more markedly open systems dominated by grasslands with environmental conditions that were punctuated by repeated and prolonged droughts (Price *et al.* 2005; 2011; Price & Webb 2006; Price 2012). The later changes at least may explain the extinction of taxa such as *Quinkana* locally.

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